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DEPARTMENT OF PHYSICS
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LEGON GHANA

TECHNICAL NOTE No. 1.

THE HEIGHT OF NIGHT TIME
F LAYER IRREGULARITIES AT
THE EQUATOR.

G. S. Kent & J. R. Koster.

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EQUATORIAL STUDY OF IRREGULARITIES IN THE IONOSPHERE

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ABSTRACT.

Observations by various workers have shown the existence of large irregularities in the night time equatorial F region, these irregularities give rise to equatorial spread F, severe radio star scintillation, and the scatter of radio waves. The experiment described in the following pages was designed to determine the height of the irregularities. The technique adopted consists in the observation at two separated stations of the diffraction pattern produced on the ground when the radio transmissions from an earth satellite pass through the irregularities. By measuring the velocity of the pattern over the ground, and relating this to the height and velocity of the satellite, the height of the irregularities is determined.

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It has been established by observations at low latitudes that there exists near the equator a belt in the F region in which large irregularities in electron density give rise to equatorial spread F (1) severe radio star scintillations (2) and the scatter of radio waves (3). Work by Hewish (4) and Briggs (5) on extra-terrestrial radio sources shows how the height of the irregularities may be inferred from observations of the diffraction pattern on the ground. But the methods used are rather indirect, and therefore subject to some uncertainty. More recently Cohen and Bowles (6) using radar techniques arrived at an estimation of irregularity heights for equatorial locations. It is not certain that these irregularities are to be identified with those responsible for satellite and radio star scintillation.

Studies of these disturbances now being pursued at University College, Ibadan, and at the University of Ghana, Accra, show that the irregularities in the pattern on the ground are elongated in the direction of the earth's magnetic field, that the axial ratio is greater than 6 to 1, and that the smaller dimension is of the order of 0.5 km. (7, 8). These results are deduced from the study of satellite and radio star transmissions through the disturbed region. It is desirable to determine the heights of the irregularities by a direct method. The procedure adopted consists in the observation at two separated stations of the diffraction pattern produced on the ground when the radio transmissions from an earth satellite pass through the irregularities. The velocity of the pattern over the ground is determined, and by relating this velocity to the known height and velocity of the satellite, it is possible to determine the effective height of the diffracting screen. Since the drift velocity of the diffracting screen itself is known to be of the order of 150 m/sec (7) it can be neglected without introducing an appreciable error.

The observations were made at Legon, near Accra, Ghana, (latitude 5° 38'N; longitude 0° 11'W), and the satellite used was Tiros II (1960 pi 1). Since its apogee and perigee distances are 724 and 624 km respectively, it is normally above the electron density maximum in the F layer. The orbit is inclined to the equator at an angle of 48.6°. The signal used was the transmission on 108.03 mc/s. At each station the signal was received on a half wave dipole, and fed to a crystal controlled converter ahead of a Collins type R.390A/URR radio receiver. To achieve a satisfactory signal to noise ratio it was necessary to employ a bandwidth of 100 cycles per second. Tuning was done manually at both receivers throughout each observation. In each case the receiver B.F.O. was used to give a 2,000 c.p.s. note, which was transmitted via telephone cable to a central recording location. The amplitudes of the signals were then displayed on a double beam oscilloscope and recorded photographically. A number of observations were made with an E-w baseline one km in length. Later a 2.4 km baseline was used, inclined 48° to the equator in the plane of the satellite orbit. Observations were limited to night time passes in the period 21st June to 13th July, 1961.

If the irregularities occur in a thin layer at a height z and the satellite is moving horizontally at a height h and a velocity V, it can be shown that the diffraction pattern will move across the ground with a velocity $V \frac{z}{h - z}$ (9). In the case of a satellite moving in an elliptical orbit round the earth, the expression is more complicated, but the velocity and direction of movement of the pattern on the ground can still be derived from a knowledge of the orbit. The time shift observed in the fading at the two aerials depends upon the relative direction of the velocity of movement of the pattern, the line joining the two aerials, and the direction of elongation of the pattern on the ground. The irregularities have been assumed to lie along the magnetic lines of force and, to a first order of approximation, to be infinitely elongated.

If the layer of irregularities is not thin, the form of the pattern will change slowly as the pattern moves across the ground, in a manner depending upon the thickness. This will cause the maximum correlation of the signals at the two aerials to be less than unity. A further decrease will occur since the pattern is not infinitely elongated and the two aerials do not lie precisely along the direction of motion of the pattern. From observations of this decrease with different aerial orientations, it is in principle possible to separate these two effects and determine the thickness as well as the height of the layer of irregularities. In practice, due to the limitations of the equipment available, the results obtained even with the aerials lying almost along the direction of motion of the pattern were not accurate enough to give more than an upper limit to the thickness. The decrease in correlation also reduces the measured time-shift slightly, and a correction was applied for this.

The rate of fading of the signals was normally of the order of 5 cycles per second during periods of scintillation when measurements were made. Time delays found over the two paths were about 0.2 and 0.4 seconds. The records were normally taken for about 5 seconds, and were read at intervals of 20 milliseconds. Cross and auto-correlation functions were calculated for the amplitudes of the signals received at the two aerials. Ten records were analyzed and the results are summarized in the table given below.

The distance given in column 3 refers to the distance along the ground from the observer to the point vertically below the irregularities observed. Column 5 shows the virtual height of the base of the F layer from an ionogram taken at Accra at the time of the observation. On all occasions on which satellite scintillations were observed, spread F and radio star scintillation were also present.

It will be noted that the effective height of the irregulatiries always lies between 50 km and 100 km above the base of the F layer. The value of height given above may be compared with the results of Cohen and Bowles (6) who found that the irregularities which they observe lie at or near the base of the F layer.

From the maximum values of the cross correlations observed the elongation of the irregularities is found to be greater than 7 to 1, and the thickness of the scattering layer to be less than 120 km.

DATE	U.T.	DISTANCE	DIRECTION OF IRREGULA-RITIES OBSERVED	HEIGHT OF BASE OF F LAYER	HEIGHT OF IRREGU-LARITIES
22/6/61	22:01:03	1169	1° W of N	350 km.	424 km.
22/6/61	22:02:01	1658	6° E	350	401
23/6/61	20:56:04	1171	37° E	360	416
24/6/61	21:27:02	913	34° W	300	402
24/6/61	21:29:00	1171	8° W	300	396
24/6/61	21:30:06	1545	7° E	300	380
9/7/61	02:33:54	697	151° E		395
10/7/61	01:22:30	788	9° E		427
12/7/61	00:51:07	415	12° E	260	354
12/7/61	00:52:07	292	46° E	260	314

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ABSTRACT: Irregularities in the night time F region cause spread F, radio star scintillation, and radio wave scattering. Observation of the diffraction pattern produced on the ground when signals from an earth satellite pass through the irregularities enables the height of the irregularities to be determined.

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